Uranium and neptunium interactions with biogenic iron minerals

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Uranium (U) and neptunium (Np) are potential radioactive contaminants. They have access to more than one oxidation state and thus display variable environmental behaviour. Under oxic conditions, the stable forms of U and Np are the relatively soluble UO_2^{2+} and NpO_2^{+} species. However, under reducing conditions, microbes have been shown to reduce U(VI) and Np(V) to less soluble forms *via* direct enzymatic reduction or through reaction with by-products of microbial reduction including Fe(II) bearing minerals.

Here, we describe pure culture geomicrobiological experiments with Fe-bearing mineral phases designed to investigate reduction mechanisms for U(VI) and Np(V) associated with biologically mediated changes in Fe mineralogy. Experiments consisted of: (A) controls where the radionuclides were exposed to ferrihydrite ($Fe_5HO_8•4H_2O$); (B) sorption experiments with the radionuclides exposed directly to sterile bio-precipitated magnetite (Fe_3O_4); and (C) co-precipitation experiments where ferrihydrite was spiked directly with UO_2^{2+} and NpO_2^{+}, and then bio-reduced. In systems (B) and (C), magnetite bio-reduction from ferrihydrite was mediated by *Geobacter sulfurreducens*. XAS was used to characterise the radionuclide speciation and co-ordination in the mineral phases. XANES data indicated that only U(VI) was present in the Fe(III) bearing control and the sorption experiment, whilst U(VI) was quantitatively reduced to U(IV) in the co-precipitation system. In contrast, quantitative Np(V) reduction to Np(IV) was observed in both sorption and co-precipitation experiments, whilst Np(V) was found on ferrihydrite.

Using MESSENGER neutron spectrometer data to identify neutron-absorbing elements on Mercury's Surface

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Galactic-cosmic-ray-induced thermal neutrons are highly sensitive to the presence of Fe and Ti on Mercury's surface. Knowing the abundance of Fe on Mercury is important for understanding key aspects of Mercury's formation and magmatic history. In addition, there is large uncertainty about the source of Mercury's low albedo, which in principle could be caused by enhanced concentrations of material rich in Fe, Ti, and/or C. [1].

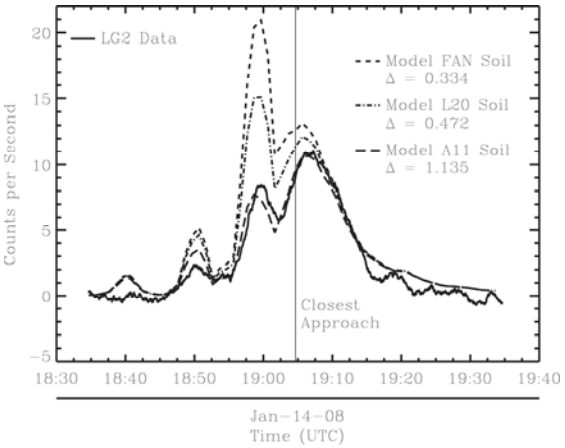

Figure 1: MESSENGER NS data (solid line) compared with modeled count rates for different lunar soils (dashed lines).

During MESSENGER's first Mercury flyby, the Neutron Spectrometer (NS) measured thermal neutrons from Mercury using spacecraft Doppler filter effects (Fig. 1). These data were modeled for lunar soil types (ferroan anorthosite, Luna 20, and Apollo 11) having different amounts of neutron-absorbing elements Fe and Ti. This preliminary modeling suggests that Mercury contains higher abundances of neutron-absorbing elements than our initial estimate that the neutron absorption was less than a total Fe equivalent of 6 wt.% [2].

[1] Denevi & Robinson (2008) *Icarus* **197**, 239. [2] Solomon *et al*. (2008) *Science* **321**, 59.